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CONTENTS

PAGE

OLDROYD, H. A Giant Bombyliid (Diptera) Bred from the Pupa of a Cossid Moth . 49–50, 6 figs.

FRASER, Lt.-Col. F. C., I.M.S., Retd., F.R.E.S. Two new species of Odonata from the Tertiary of Radoboj . . . . . 51–52, 2 figs.

SPEYER, E. R., M.A., F.R.E.S. Gladiolus Thrips (*Taeniothrips simplex* Mor.) in England . . . . . 53–62, 7 figs.

MENON, M. A. U. On certain little-known external characters of adult Mosquitoes and their taxonomic significance . . . 63–71, 3 figs.

BOOK NOTICE 72

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A GIANT BOMBYLIID (DIPTERA) BRED FROM THE PUPA OF A COSSID MOTH.

By H. Oldroyd.

In 1947, in Malaya, Mr. H. T. Pagden collected a pupa of a Cossid moth from which he bred a pair of Bombyliidae of abnormally large size and striking appearance. These were submitted to the Commonwealth Institute of Entomology, who passed them on to me for study.

The fly belongs to the tribe Exoprosopini, and is notable for the greatly reduced mouthparts (fig. 3). In this and in other details of head structure it falls within the genus *Oestranthrax* Bezzi, which was erected for *Anthrax obesus* Loew, from S. Africa. Paramonow has described a number of species from Arabia and Asia, but so far as I know none has yet been described from the Far East. The present species, besides being much larger than those previously known, is strikingly different in its general appearance.

Oestranthrax goliath sp. n.

A giant Bombyliid, in bulk of body the largest known to me. Entire body and legs a rusty brown in ground-colour, but thickly covered with black scales and hairs, so that the whole appearance is deep black, without pattern. Wings rusty-yellow, veins yellow, and membrane stained.

♂♀. *Head* (figs. 1–3): Ocellar triangle small but prominent, especially in male, with three ocelli. Frons with short, thick black scaly hairs. Face with fine black hairs and thick white scales, except for a narrow median line which has black scales (♂), or with only a few white scales at sides (♀). Oral opening much reduced, proboscis and palpi vestigial but distinct. Vertex deeply notched, with a triangle of white scales on each side. Occiput broad, with black scales. Posterior eye-margin bisected, with a shallow indentation, which is filled with a triangle of white scales. Antennae (fig. 5): all black; first segment with long, black bristly hairs, especially ventrally; third segment somewhat bulbous basally, continued as a long, stout style with a microscopic bristle at tip.

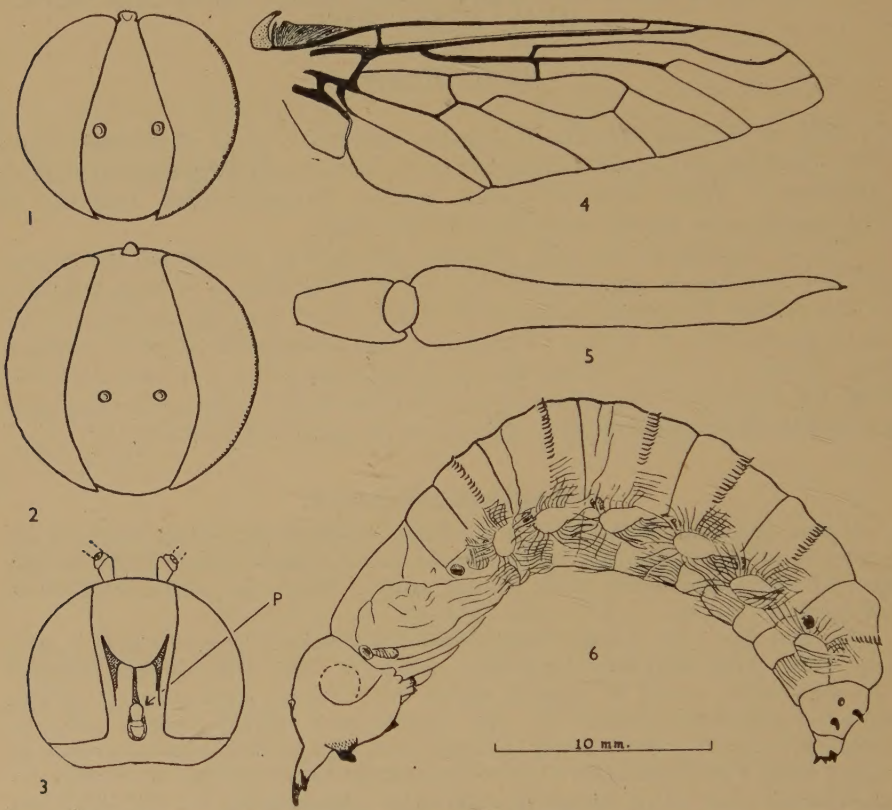
Thorax: Mesonotum dark rusty red in ground-colour, but in life entirely covered with black scales closely applied to surface, with erect black hairs fairly sparse on disc, thicker and more tufted round collar and side margins; no bristles. Scutellum similar. Some greyish hairs in supra-alar and postalar tufts. Pleura rather reddish in ground-colour, with thick tufts of black hairs, especially on dorsal half of pleura; white patch in mesopleural tuft; metapleura with small black tuft. Haltere with brownish stem and mahogany-red knob.

Abdomen: Dorsally with seven clearly visible tergites, and eighth partly visible. Rusty black in ground-colour, becoming more rusty red on apical tergites. Adpressed scales are longer and more hairlike than on thorax. First tergite and anterior half of second tergite with erect brownish hairs. Fifth and sixth tergites with a thick fringe of brownish hairs along hind margin, lying horizontally, and partly overlapping following tergite. Seventh tergite clothed with brownish hairs in two transverse fringes. The smaller eighth tergite in both sexes orange, with a pair of marginal tufts of orange hair.

Venter similar, but seventh sternite is last visible, and bears yellow hairs on its hind margin. Genitalia yellow.

Legs : Rusty black, thickly encrusted with black scales. Femora without spines. All tibiae with numerous spicules. Tarsi slender, tapering, with simple claws and no pulvilli.

Wings : Rather pointed, with a straight hind margin, pale yellow, with rust-yellow veins. Tegular tuft mixed black and white scales. Basicosta strongly curved, hooklike.



FIGS. 1–6.—(1) Frons of male ; (2) frons of female ; (3) head of male from ventral side, showing vestigial proboscis, *P* ; (4) right wing ; (5) antenna of female ; (6) lateral view of pupa. Scale applies to pupa only.

Basal comb broad, black. Venation as in fig. 4 ; third posterior cell longer than in the genotype of *Oestranthrax*.

Length : Body 24 mm. ; *wing* 20 mm.

Holotype ♀ and paratype ♂ and one empty pupal skin from MALAYA : Oenang-Balik, Pulau, 29.12.1947. Collected from a Cossid pupa (*H. T. Pagden*). Presented to the British Museum (Natural History).

The puparium is figured (fig. 6), but not described in detail. Note the bifurcate anterior cephalic spines, and abdominal hair-tracts.

The general appearance of this fly strongly suggests a nocturnal or at least a crepuscular habit.

TWO NEW SPECIES OF ODONATA FROM THE TERTIARY OF RADOBOJ.

By Lt.-Col. F. C. Fraser, I.M.S., Retd., F.R.E.S.

I am indebted to Madame and Dr. F. Carpentier of the Liége University Museum for the opportunity of examining two fossil wings of Odonata, representing two new species of Libellulidae, one of which I have named in honour of Madame Lejeune Carpentier, conservator of the palaeontological collections in the Liége University Museum. Both fossils come from the Tertiary of Radoboj, Croatia, and both represent the left hind wings of a libelluline, although not of the same genus and species. The undamaged parts of the impressions are in a fine state of preservation and impressed on a fine-grained matrix. The high level of evolution depicted in the venation of these two wings, which is equal to that of any present-day dragonfly, clearly shows that the venation had reached its zenith of perfection many thousands of years ago, and has remained practically static ever since.

Lithemis lejeune-carpentieri sp. n.

The fossil represents the left hind wing of a dragonfly with about the apical fifth missing, and belonging to the family Libellulidae. The portion of costa still preserved is about 22 mm. in length, the total length being probably about 30 mm. and the expanse some 60 mm. (rather smaller than *Libellula depressa* Linn.). The venation is very recent, the anal loop highly developed, with a maximum of 4 cells between the midrib and anal vein and 2 rows of cells between the midrib and Aiii, a formation closely similar to that found in some of the recent forms of *Neurothemis* Brauer or *Rhyothemis* Hagen. There are both radial and medial supplements, but with only a single row of cells between them and IRiii and MA respectively; the arculus is recessed to the level of the basal antenodal (a level found only in the most recent living Libellulidae). Traces of a dark brown pigment are noted in parts of the wing, and this accentuates the relationship which exists between this new genus and the two genera *Neurothemis* and *Rhyothemis*, in many species of which the wings are more or less broadly pigmented.

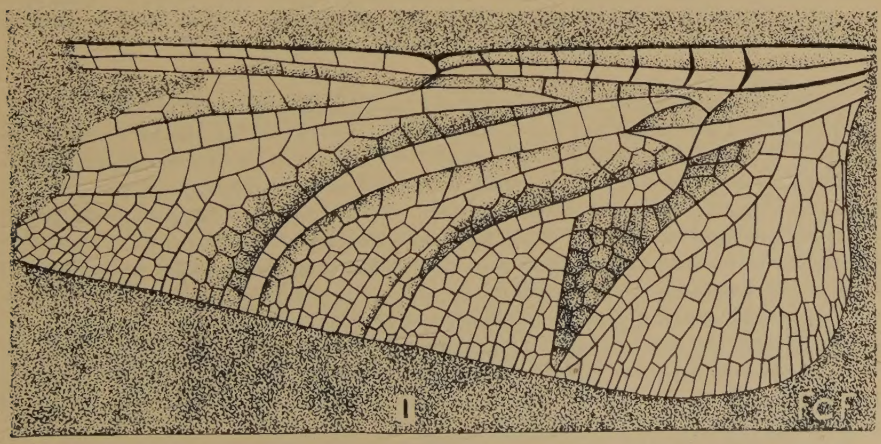


Fig. 1.—Base of hind wing of *Lithemis lejeune-carpentieri* sp. n. Lower Miocene, Radoboj. (× 5·75.)

Holotype : Specimen No. 14726, Liége University Museum, Lower Miocene of Radoboj, Croatia.

Oligocaemia imperfecta sp. n.

The species is represented by the greater part of the left hind wing (obverse impression) and a portion of the base of the right hind wing, the two connected by an indefinite mass which is obviously the intervening thorax of the insect. The left wing is beautifully preserved save for the apical fourth, which is missing, and two minor portions of the basal margin. The costal margin is unbroken to as far as the proximal end of pterostigma, a portion of which is preserved. Beyond this, some portions of the apical terminals of the main veins can be traced, showing the apex of the wing to be obtusely pointed but hardly falcate. The venation is recent, and its evolution equals the highest level attained by present-day Libellulines of the *Tramea* group, which latter Ris placed as the most recent of all genera in the family LIBELLULIDAE. The postnodal portion shows a well-

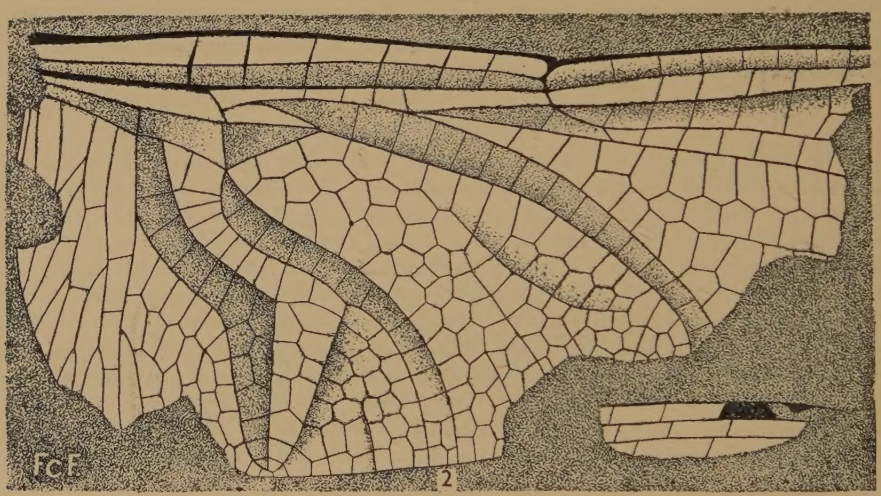


FIG. 2.—*Oligocaemia imperfecta* sp. n. Portion of left hind wing (obverse) with apical part of costal border, including remnants of pterostigma. Lower Miocene, Radoboj. (× 3·5.)

developed radial supplement, Rspl, separated from IRiii (Rs) by 2 rows of cells. Similarly, in the discoidal field, there is a well-developed Mspl separated from MA by 2 rows of cells. A highly developed anal loop is closely similar to that seen in the recent genus *Rhyothemis* Hagen, and the presence of pigment on the fossil wing serves to emphasize the close relationship which appears to exist between the two. The discoidal cell has its base slightly but distinctly proximal to the level of the arculus, which latter lies between the 1st and 2nd antenodals as in most recent Libellulines. From the base to the rather indefinite apical ends of the longitudinal veins is about 40 mm., giving an expanse of about 80 mm.—that is, roughly equal in size to *Libellula depressa* Linn. The base of the right wing is poorly defined, and apart from the main veins only a small cellular area can be made out : it covers the base up to the base of the discoidal cell, bounded anteriorly by the anal vein, and distally comprises the major part of the anal loop, in which area the venation seems to be similar to that in the left hind wing.

Holotype : Specimen No. 14727, Liége University Museum, Lower Miocene of Radoboj, Croatia.

GLADIOLUS THRIPS (*TAENIOTHRIPS SIMPLEX* MOR.) IN ENGLAND.

By E. R. Speyer, M.A., F.R.E.S.

The Gladiolus Thrips was first recorded as a pest of Gladiolus in 1929, both in Ontario, Canada, and at Cleveland, Ohio (U.S.A.); specimens obtained in these localities were described under the name *Taeniothrips gladioli* by Moulton and Steinwenden in 1931.

In the meantime, Morison (1930) had received females of an undescribed species of *Taeniothrips* (found upon flowers of carnation in September, 1928) amongst a collection of Thysanoptera from South Australia, and described this species under the name *T. simplex*. Later it was established that the insects from N. America and Australia were similar, and the specific name *simplex* Mor. therefore holds priority.

During subsequent years severe infestations upon Gladiolus occurred practically throughout Canada and U.S.A., in Hawaii, South Africa and Australia.

This wide distribution is more likely to have been brought about through transportation of corms, upon which the insect is known to live and breed during the period of storage, than by its own apparently limited powers of dispersal.

There would appear to be no records of *T. simplex* from any European country, and it is indeed surprising that a pest elsewhere so widely distributed should now for the first time have made its appearance in England.

Occurrence in England.

On 27th July, 1950, foliage and flower-spikes of Gladiolus from a small market garden at Edmonton, Middlesex, were submitted to me for examination. The greater portion of the leaves and of any exposed petals presented the silvery appearance associated with "thrips" injury; the flower petals had failed to expand, and showed severe distortion. Large numbers of adult "thrips" were situated upon the exposed portions of leaves and petals, 2nd instar larvae within flower sheaths and amongst petals, and a few 3rd instar nymphs had secreted themselves within folded-over apices of the leaves. The adults, which had been exposed to bright sunlight for some time, were inactive, and did not take to flight when disturbed. Of a total of 71 adults collected, only 8 were of the male sex.

From a microscopic examination of the adults, it was apparent that the insects belonged in the genus *Taeniothrips*, but not to a species known to occur in Europe.

Reference to Morison's (1930 : 12–13) description of *T. simplex* and subsequent comparison with the female type and co-type specimens from Australia

in the British Museum collection left no doubt as to their identity with that species.

A visit to the market garden at Edmonton revealed an infestation of some thousands of plants, which were closely planted in rows, and of which the earlier had suffered much greater injury than the later-flowering varieties.

It was ascertained that the majority of corms from which all the plants had been raised had been obtained from Holland four years previously, that a similar but much less severe infestation had been noticed during the first flowering season, and that during the winter of 1949–50 the corms had been stored in a heated greenhouse.

During August, through the good offices of the Plant Pathological Laboratory at Harpenden, small collections of Thysanoptera from Gladiolus plants in Berkshire, Gloucestershire and Lincolnshire were obtained. All contained adult females of *T. simplex*, and in one a few 3rd and 4th instar nymphs (prepupae and pupae) were also present. Other Thysanoptera represented were single females respectively of *Acolothrips fasciatus* L., *Limothrips cerealium* Hal. and *Thrips flavus* Schr.

On 21st September a second visit was made to the market garden at Edmonton. The infestation had been greatly reduced, partly no doubt by recent heavy falls of rain, and partly by application of sprays containing DDT. There appeared to be few fresh feeding marks upon the foliage, and the later-flowering varieties had formed good blooms. The petals of pink and red flowers had, however, been scored to some extent by the insect. One of these flowers contained a male and 14 females, which were very active, and some of which jumped, but did not take to flight when disturbed ; no larvae were contained in the flower. In other flower-spikes, males and females were situated upon the inner surface of the flower sheaths, and many 1st and 2nd instar larvae amongst the petals of opening blooms and of older dying and dead flowers low down upon the spikes. Many eggs were located : the majority had been inserted into the tissues of the inner surface of the sheaths surrounding unexpanded flowers, and a smaller proportion occurred in the outer surface of petals immediately underlying the sheaths.

From large areas of their exposed portions, the pigment had been entirely removed from the petals by the larvae, indicating that the latter had been feeding gregariously and were probably responsible for most of the injury caused.

Several 3rd and 4th instar nymphs lay side-by-side under the turned-in edge at the apex of a leaf, accompanied by an adult male ; apart from these no adults or larvae were found upon the foliage. From the comparatively small number of " pupae " obtained from leaves and flower-spikes, it was considered probable that the majority of 2nd instar larvae had descended to the ground when they had become full-fed.

Neither adults nor young stages were found upon corms of the earlier flowering varieties, which had recently been lifted for storage.

From the opening flowers of spikes which had been kept in a vase for a period of one week, some hundreds of 1st and 2nd instar larvae were obtained, but no adult males and only two females could be found. It was concluded that the majority of the adults had flown away not long after the spikes had been cut from the plants.

Habits and Life-History.

E. A. Herr (1934) has given a detailed account of the habits and life-history of the Gladiolus thrips in Ohio, from which the following salient features are taken :

1. The adult insects are sluggish,[1] and there is little movement from plant to plant before the flowering period. When later an infestation becomes severe, considerable migration by flight may take place. The sexes may occur in equal proportions, and the males are polygamous: normally but few females are unmated. Unmated females deposit eggs the young from which all develop to adults of the male sex, and the progeny of females mated with their own offspring are of both sexes.

2. The 1st and 2nd instar larvae of the summer generations feed gregariously beneath the leaf-sheaths, but when very numerous they occupy exposed positions upon the foliage. When full-fed, the 2nd instar larvae seldom descend to the ground, like those of many Thysanoptera, and the great majority of 3rd and 4th instar nymphs (" prepupae " and " pupae ") are to be found concealed at the upper extremities of the leaf-sheaths and amongst petals of opening flowers.

3. Smith and Nelson (1933) give the average duration in days for each stage during the summer months as follows : Egg, 4·66 ; 1st and 2nd instar together, 3·78 ; 3rd and 4th instar together, 6·61 ; total 15·5 days. Nine generations were completed between 10th June and 15th October, giving an average duration of 2 weeks for each generation. The insect thrived best under hot, dry conditions, and heavy rains effected a considerable decrease in the population, especially of the adults.

4. In autumn adults descend to the corms, and under favourable conditions of temperature continue to breed and to cause considerable and sometimes fatal injury to them while they are in storage. The insect was unable to survive the winter upon corms left in the ground out-of-doors.

5. When kept at a constant temperature of 50° F., some eggs, which had been deposited in leaves, hatched after an average period of about 23 days, but all the larvae succumbed while still in the 1st instar.

At constant temperature levels between 59° F. and 86° F., the majority of eggs hatched, the average incubation periods at these temperatures being respectively about 13 and 3 days. At 59° F. some 1st instar larvae survived and at this temperature completed their development to the adult stage upon the corms. The rate of development was progressively accelerated at higher levels of temperature up to 86° F.

The duration of development from egg to adult at different temperature levels is represented by the graph shown in Fig. 1.

The optimum temperature for development, based upon the survival factor, was computed to be in the region of 77° F.

Diagnostic Characteristics.

Taeniothrips simplex Mor. is, as far as can be ascertained, the only Thysanopteron which causes any severe injury to Gladiolus, at least in England.

[1] Watson (1934 : 2) states that in Florida the adults were very active and readily took to flight.

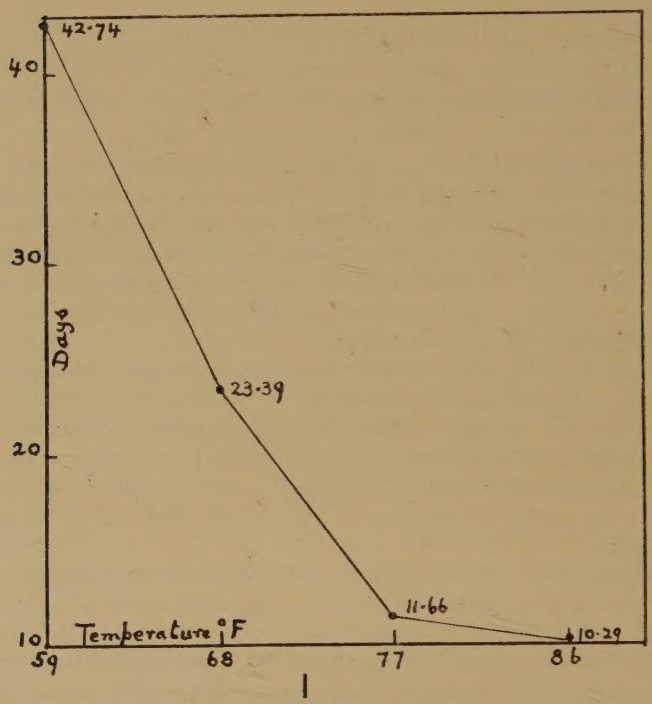


Fig. 1.—*Taeniothrips simplex* Mor. Average duration of development from egg to adult at constant levels of temperature on Gladiolus corms. From E. A. Herr (1934 :13).

From the general nature of its foliage, some of the grass-inhabiting species, particularly of the genus *Limothrips*, which infest maize and sweet-corn might be expected to select the Gladiolus as a host-plant, but only isolated adults of *L. cerealium* Hal. have been obtained in collections made during the summer months.

A random collection of Thysanoptera exposed upon the petals of Gladiolus flowers in a Hertfordshire garden on 29th July, 1950, contained the following species : *Aeolothrips fasciatus* L., 14 ♂, 40 ♀ ; *Ae. tenuicornis* Bagn., 2 ♂, 3 ♀ ; *Limothrips cerealium* Hal., 1 ♀ ; *Taeniothrips atratus* Hal., 1 ♂, 3 ♀ ; *T. vulgatissimus* Hal., 1 ♀ ; *Thrips physapus* L., 1 ♀ ; *T. major* Uz., 6 ♂, 8 ♀ ; *T. tabaci* Lind., 4 ♀. The flowers were not examined for larvae, but a number of dried-out specimens of the three species of Thrips indicated that those of *Aeolothrips*, which are predatory, were present in the flowers. In spite of this considerable population, there was no trace of any injury to the flowers or foliage.

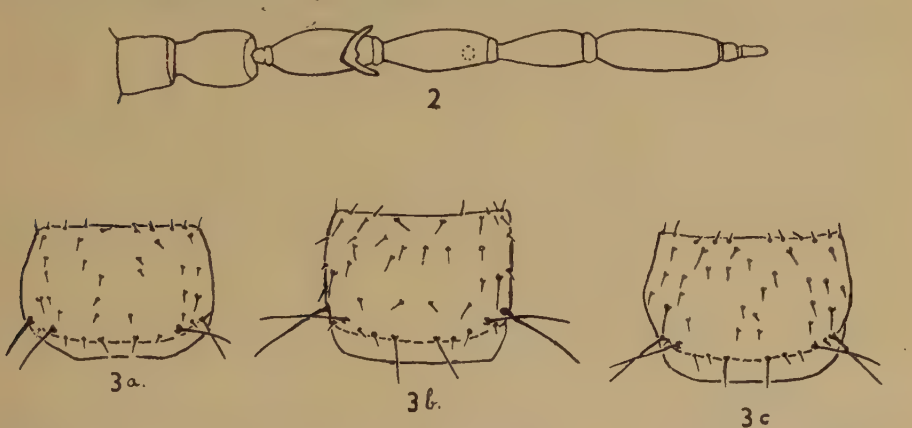
All the Thysanoptera contained in them were extracted from two open pink flowers in Northumberland on 8th August ; they comprised : *Taeniothrips atratus* Hal., 5 ♂ ; *T. vulgatissimus* Hal., 1 ♂, 3 ♀ ; *Thrips fuscipennis* Hal., 5 ♂, 11 ♀ ; *T. tabaci* Lind., 1 ♀ ; *T. flavus* Schr., 1 ♂, 4 ♀. No larvae were found, and such feeding marks as occurred upon the petals were hardly noticeable.

It appeared probable that none of our indigenous Thysanoptera, other than predatory forms, are likely to breed upon Gladiolus, and that those

species which are known to be injurious to other plants merely assemble together in the flowers and feed little except perhaps upon the nectar and pollen.

Any severe " silvering " of the foliage and petals of Gladiolus will therefore afford an almost certain indication that the plants are infested by *T. simplex*.

The genus *Taeniothrips*, an unsatisfactory one as at present constituted—since it is not with certainty separable from the genus *Thrips*—is defined as containing species which possess an 8-segmented antenna, with the two terminal segments forming a " style " (fig. 2), and two setae at each posterior lateral angle of the pronotum which are longer and stouter than those upon the remainder of its surface (fig. 3). Species in the genus *Thrips* exhibit the latter characteristic, but in some of them the antennal style may be either one- or two-segmented (cf., *T. flavus* Schr. and *T. alni* Uz.).



FIGS. 2–3.—Diagnostic characteristics for *Taeniothrips*. (2) *T. atratus* Hal. ♂. Outline of antenna (dorsal aspect) × 260. (3) Chaetotaxy of pronotum, × 120. (*a*) *T. simplex* Mor. ♀; (*b*) *T. atratus* Hal. ♀; (*c*) *T. vulgatissimus* Hal. ♀.

The only British species of *Taeniothrips* with which *T. simplex* might be mistaken are *T. atratus* Hal. and *T. vulgatissimus* Hal., both of which are often excessively abundant in the flowers of many wild and cultivated plants.

The following characteristics are common to the three species, and serve to separate them from other British species of the genus :

In both sexes the 3rd to 7th abdominal sternites (3rd to 8th in the males) are beset with " accessory " setae (figs. 4 and 6), and there are 3 setae along each lateral margin of the 2nd abdominal tergite (fig. 5); the terminal segment of the fore-tarsus is devoid of a hook-like process.

In the males there is a clear and pitted depression upon each of the 3rd to 7th abdominal sternites (fig. 6),

In the females there is a complete fringe of microtrichia across the posterior margin of the 8th abdominal tergite, though rarely this may be only partially developed or entirely wanting in aberrant specimens of *T. atratus*.

The most constant characteristics by which the three species may be separated from one another are as follows :

T. simplex :

Male : Depressions on abdominal sternites transversely elongate, exceptionally large, that on 3rd sternite 20–30μ × 130–150μ (fig. 6*a*).

Female : 3rd to 7th abdominal pleurotergites devoid of accessory setae (cf. fig. 5) ; microtrichia on posterior margin of 8th abdominal tergite not exceeding 10μ in length. *Outer* seta at posterior lateral angle of pronotum 50–70μ long (fig. 3*a*). Main-vein of forewing beset with 4–8 setae in its distal half (fig. 7*c*).

T. atratus :

Male : Depressions on abdominal sternites transversely elongate, of moderate size, that on 3rd sternite 15–20μ × 60–90μ (fig. 6*b*).

Female : 3rd to 7th abdominal pleurotergites beset with long accessory setae (fig. 5) ; microtrichia on posterior margin of 8th abdominal tergite (when present) not exceeding 10μ in length. *Outer* seta at posterior lateral angle of pronotum 90–110μ long (fig. 3*b*). Main-vein of forewing beset with 5–11 or more setae in its distal half (fig. 7*a*).

T. vulgatissimus :

Male : Depressions on abdominal sternites oval, of moderate size or small, that on 3rd sternite 15–30μ × 40–80μ (fig. 6*c*).

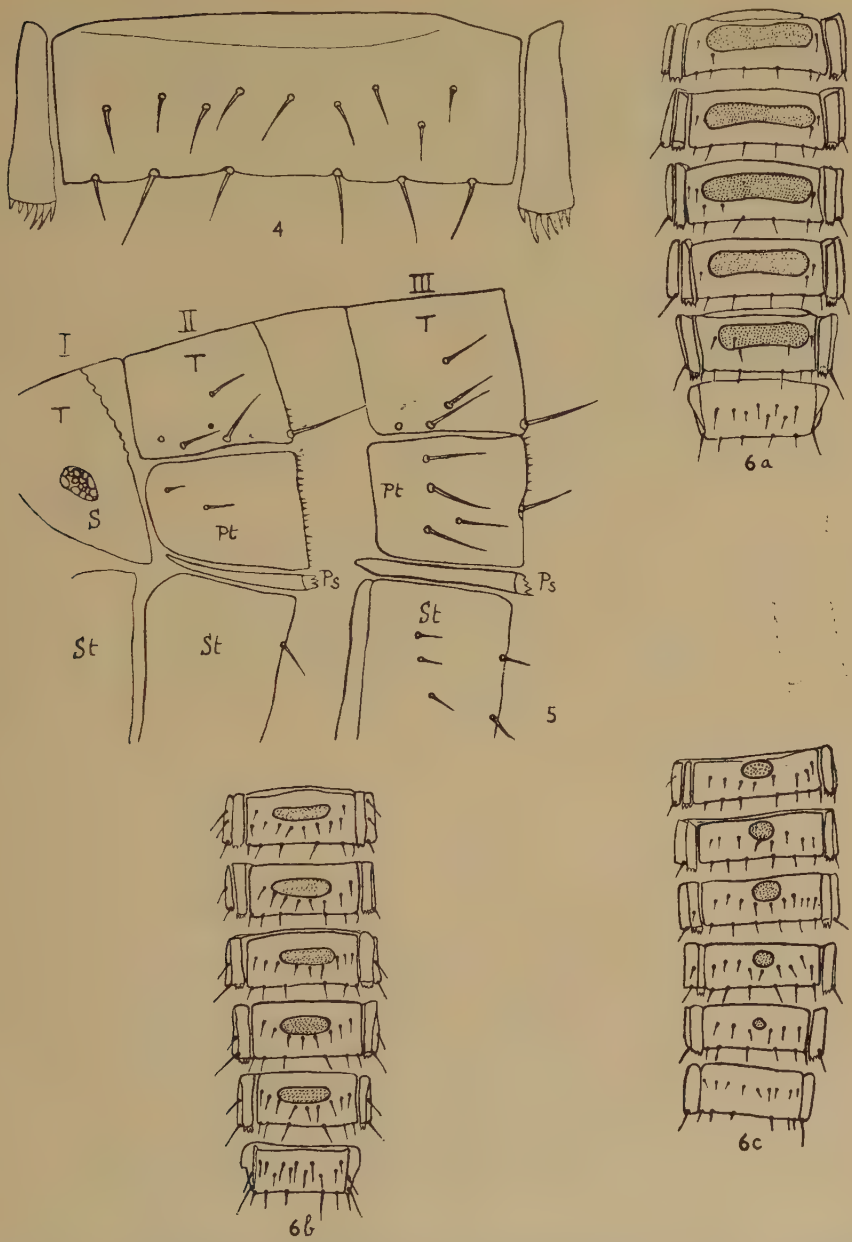
Female : 3rd to 7th abdominal pleurotergites beset with long accessory setae (as in fig. 5) ; microtrichia on posterior margin of 8th abdominal tergite 15–20μ long. *Outer* seta at posterior lateral angle of pronotum 80–100μ long (fig. 3*c*). Main-vein of forewing beset with 2–4 setae in its distal half (fig. 7*b*).

Some reference may be made to other differences which cannot, however, be employed with any degree of certainty for separation of the three species. In general dimensions the males of all are very similar, the overall length being 1·2 to 1·4 mm., and the breadth across the pterothorax 0·25 to 0·35 mm. Females of *T. simplex* are usually rather smaller than those of the other two species : the former have an overall length of 1·4 to 1·75 mm., and the latter of 1·5 to 1·9 mm., the breadth across the pterothorax for all being 0·3 to 0·4 mm. In both sexes, but more so in the females, the greater portion of the forewing of *T. simplex* and *T. atratus* is usually suffused with grey or brown, that of *T. vulgatissimus* less strongly with brownish-yellow. The setae upon the body generally and upon the wing-veins are rather shorter in *T. simplex* than in the other two species.

Larvae of *T. simplex* in the 2nd instar are characterized by the total absence of sclerotized areas or spots from the dorsal surface of the three thoracic somites, and the very short processes upon the posterior margin of the 9th abdominal somite, which do not exceed 5μ in length and are of uniform size. In all other respects they resemble those of *T. vulgatissimus* (*see* Speyer and Parr, 1941 : 612).

Conclusion.

The Gladiolus Thrips is a dark reddish-brown insect, the males of which are about 1·3 mm. and the females about 1·5 mm. in length. The adults are normally very active when disturbed, but may become sluggish at higher temperatures if exposed for long to sunlight. For the most part, they live concealed within the doubled-over young leaves, within the flower sheaths,



FIGS. 4–6.—Diagnostic characteristics for species of *Taeniothrips*. (4) *T. vulgatissimus* Hal. ♀. Chaetotaxy of 4th abdominal sternite (with pleurosternites) × 240 (similar in *T. simplex* and *T. atratus*). (5) *T. atratus* Hal. ♀. Chaetotaxy of 1st to 3rd abdominal somites, viewed from left side, × 240 (in *T. simplex* the 3rd to 7th pleurotergites are devoid of accessory setae). Ps. pleurosternite; Pt., pleurotergite; S, spiracle; St, portion of sternite; T, portion of tergite. (6) Males: 3rd to 8th abdominal somites in ventral aspect × 100, showing depressions and accessory setae on sternites. (*a*) *T. simplex*; (*b*) *T. atratus*; (*c*) *T. vulgatissimus*.

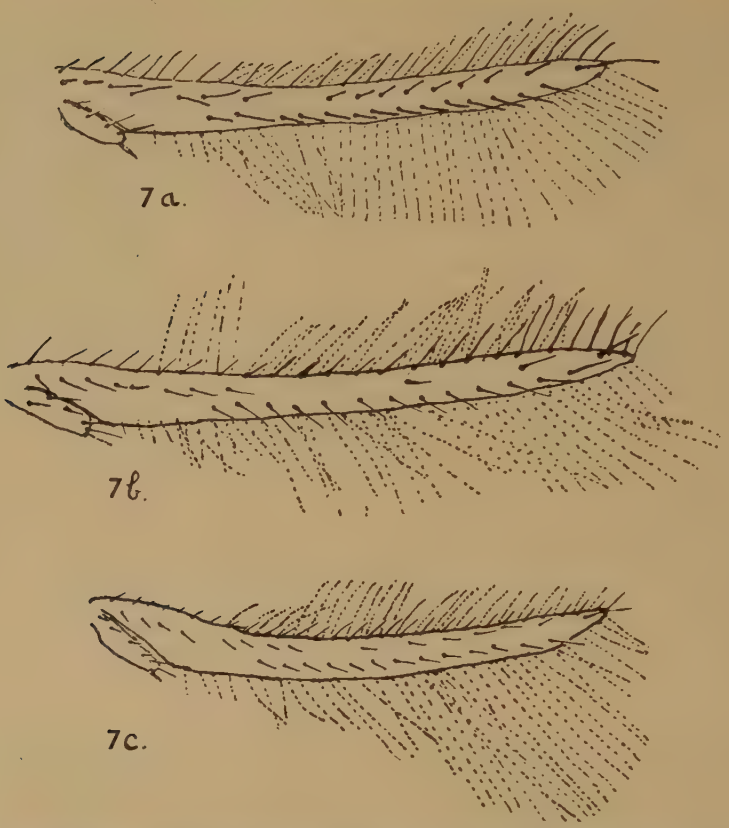


Fig. 7.—Diagnostic characteristics for species of *Taeniothrips*. Females: Chaetotaxy of right forewing × 80. (*a*) *T. atratus*; (*b*) *T. vulgatissimus*; (*c*) *T. simplex*.

and amongst the petals of opening flowers. In autumn they descend below the soil-surface and will continue to feed and breed upon the corms while they are in storage throughout the winter months, provided that they are not subjected to temperatures below about 50° F. for any length of time; in temperate or cold climates they do not appear to be able to survive the winter either upon plants or in the soil.

Unfertilized females will lay viable eggs, and their progeny all develop to adults of the male sex; the latter mate with their parents which then produce offspring of both sexes, with a strong tendency for the females to outnumber the males. In this manner an infestation may be started by a single unmated female. The eggs are inserted, one by one, into the tissues of young leaves, into the inner surfaces of flower-sheaths, probably less often into the petals of opening flowers, and during winter into the more succulent tissues of the corms. The yellow larvae feed, often gregariously, upon the leaves and flower petals, which assume a silvery appearance, due to the extraction by suction of the cell contents, including chlorophyll and colouring matter, and subsequent entry of air into the plant tissues; flowers also

become deformed or fail to expand their petals. The period of feeding extends over 7 to 12 days in summer. In the 3rd and 4th instars (" prepupae " and " pupae "), during which they neither feed at all nor move about to any extent, the nymphs are secreted usually beneath inturned edges towards the tips of the leaves, or between overlapping leaves, but it is probable that many 2nd instar larvae descend to the ground and complete their metamorphosis beneath the soil surface.

During warm weather a generation is likely to be completed in about 14 days, so that a severe infestation may arise already at the time at which the early-flowering varieties are forming the flower-spikes.

Although now recorded for the first time in Europe, it is highly probable that the insect has existed on the Continent for a number of years, and on several previous occasions has been imported into England upon corms from one or other of those countries. Its inability to survive the winter except under especially favourable and artificial conditions would prevent the insect from establishing itself as a permanent inhabitant of the British Isles. A succession of exceptionally mild winters has doubtless facilitated survival upon stored corms, and, more important, enabled a number of generations to be produced before the earlier varieties of Gladiolus have come into flower. The possibility of its survival out-of-doors during even a moderately cold winter would appear to be out of the question, even if the insect became temporarily established upon Iris, which is cited as a host plant by Herr (1934 : 16).

After the pest has made its appearance upon Gladiolus, it is obviously one which is liable to cause very severe losses to the commercial grower. Concealed as the insect is between the unexpanded leaf-blades and within the flower sheaths, chances of bringing an infestation under immediate control are slight. In New South Wales, Friend and Pasfield (1945) effected a reduction by over 95 per cent. of the adult population by a single application of a 1 per cent. DDT dust, and state that a spray containing 0·1 per cent. DDT was equally effective. But repeated applications at weekly intervals necessary to reduce an infestation sufficiently in order to obviate injury caused by the larvae to the flowers would entail considerable expense, at least over any large areas of plants.

According to Brooks and Anderson (1947) powders containing 1 per cent. γ-isomer of benzene hexachloride applied to plants at a time at which the petals were beginning to show at the ends of the flower-buds gave a far higher mortality amongst the insects than sprays containing either BHC or DDT in suspension. O'Kane (1947) also found that one application of a powder containing 0·5 per cent. γ-isomer of BHC was effective in bringing an infestation under control.

Riddance of the pest from nurseries and gardens ultimately depends upon the corms being kept in storage at a temperature not exceeding 50° F., with the additional precaution of sprinkling white-flake naphthalene over the corms at the rate of about 1 ounce (but not more) to 100 corms or 1 lb. to the bushel (Herr, 1934 : 59). The latter treatment will not cause injury to them during the earlier period of their storage, and will destroy, in the course of 3–5 weeks, adult insects which might otherwise survive at still lower temperatures (Hamilton, 1934).

Summary.

The history and world distribution of Gladiolus Thrips is briefly reviewed. The occurrence of *Taeniothrips simplex* Mor. in England (and Europe) is recorded for the first time, with notes upon the habits of and injury caused by the insect upon a market garden at Edmonton, Middlesex.

Essential details of the biology are summarized from publications of American authors. Records of other Thysanoptera which occur upon but are not harmful to Gladiolus are given. Diagnostic characteristics by which *T. simplex* may be separated from some common British species of the genus are set out.

Reference is made to methods by which infestations may be brought under control.

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ON CERTAIN LITTLE-KNOWN EXTERNAL CHARACTERS OF ADULT MOSQUITOES AND THEIR TAXONOMIC SIGNIFICANCE.

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The purpose of this paper is to invite attention to certain interesting characters in the external morphology of adult mosquitoes, which have not yet been adequately studied. They are as follows :

1. The presence of two rows of bud-like sensillae along the under-surface of the tarsi.[1]
2. Secondary sexual modification of the fifth foretarsal segment of the male.[1]
3. The presence of hairs on the dorsal aspect of the remigium or stem-vein.

Careful examination of a considerable amount of material, mainly Indian species, has indicated that these characters are possibly of taxonomic importance. Altogether 42 species of culicines belonging to 11 genera, and 18 species of anophelines, all of the genus *Anopheles*, have been studied. The table shows the various systematic divisions studied and the number of species representing each. The species are listed in the Appendix.

1. Bud-like Sensillae on Tarsi (fig. 1).

In his definition of the subgenus *Indusius*, Edwards (1934) has referred to the presence in *Aëdes* (*Indusius*) *pulverulentus* of " a double row of microscopic spinules along the under surface of segment 1 of front tarsus." During the present study it has been observed that such spinules are characteristic of all mosquitoes (fig. 1, *a*) except species of *Megarhinus*.

Under high magnification what Edwards has termed " microscopic spinules " are seen to be bud-like structures, each of which consists of a central seta enclosed within two short-pointed " stipules " (fig. 1, *b*, *c*, *d*). Obviously these structures are sensory in function, even though the true nature of their function is not known. To distinguish them from other kinds of sensillae occurring on the tarsi, they are hereafter referred to as " bud-like sensillae."

As already stated, the bud-like sensillae are characteristic of all mosquitoes, except species of *Megarhinus*. One notable and constant difference has been observed as between anophelines and culicines. That is, while the anophelines have the sensillae on the front tarsus only, the culicines have them on both the front and the mid tarsi, and rarely, as in the subgenus *Mansonioides*, on the hind tarsus too. In the light of this observation, it would be natural to expect their presence on the mid-tarsus of *Aëdes* (*Indusius*) *pulverulentus*

[1] These characters become clear only in potash-cleared preparations.

Tribes.	Genera.	Subgenera.	(Number). Species
Megarhinini	*Megarhinus*	*Megarhinus*	1
Culicini	*Tripteroides*	.	1
,,	*Harpagomyia*	.	1
,,	*Theobaldia*	*Allotheobaldia*	1
,,	*Ficalbia*	*Ficalbia*	1
,,	,,	*Mimomyia*	2
,,	*Mansonia*	*Mansonioides*	4
,,	*Aëdomyia*	.	1
,,	*Aëdes*	*Finlaya*	1
,,	,,	*Stegomyia*	2
,,	,,	*Aëdimorphus*	4
,,	,,	*Banksinella*	1
,,	,,	*Aëdes*	2
,,	*Heizmannia*	.	2
,,	*Armigeres*	*Armigeres*	1
,,	*Culex*	*Lutzia*	1
,,	,,	*Neoculex*	1
,,	,,	*Mocthogenes*	1
,,	,,	*Lophoceratomyia*	2
,,	,,	*Culiciomyia*	2
,,	,,	*Culex*	10
Anophelini	*Anopheles*	*Anopheles*	4
,,	,,	*Myozomyia*	14

as well, even though Edwards (*loc. cit*) mentions their presence on the front tarsus only. This would be worth verifying.

It is the first and the second tarsal segments that carry the sensillae in a regular double row, the other segments, if at all, showing only a sprinkling of them. The number of sensillae in a row does not appreciably vary among individuals of the same sex and species, but there is considerable variation in their number among different species and between sexes of the same species, the females having a larger number. In culicines, where the sensillae occur on the mid-tarsus also, their number on this is always less than on the fore-tarsus, and when all the three pairs of tarsi carry the sensillae, as in *Mansonioides*, there is a progressive numerical decrease from the fore to the hind tarsi.

2. Secondary Sexual Modification of the Fifth Fore Tarsal Segment of the Male (fig. 2).

Barraud (1926 and 1934) has described and figured the remarkable specialization of the male tarsi which is so characteristic of certain species of *Uranotaenia*. But the specialization of the fifth foretarsal segment of the male, which is more or less a common feature of most species of mosquitoes, has not received enough attention. Apart from the illustrations of the fifth tarsal segments in the male and female of 9 species of culicines given by Hardenburg (1922) without any comment, the present writer has not come across any reference to this subject. It is, therefore, thought worth while to deal with it in some detail.

FIG. 1.—Bud-like sensillae on tarsi of mosquitoes: (*a*) Fore-tarsus of *Culex bitaeniorhynchus*, showing the bud-like sensillae on the posterior side (Scale *2*); (*b*) *Culex* (*Lutzia*) *fuscanus*, highly magnified (Scale *1*); (*c*) *Culex bitaeniorhynchus* (Scale *1*); (*d*) *Anopheles hyrcanus* var. *nigerrimus* (Scale *1*).

The fifth fore-tarsal segment of the male in most species is strikingly different from that of the female (fig. 2, *a*, a_1). While in the female it is a simple piece, in the male it is provided with a distinct concavity along the posterior margin. This concavity is very often continuous with a basal prominence which carries several spines and bristles. Just below the tip of the segment is a notch which accommodates the bases of the claws when they are closed over the segment.

Usually in culicines, the aforesaid specialization may be seen, though much less conspicuously, in the mid-tarsus also; but in anophelines it is limited to the fore-tarsus.

The basal prominence in anophelines bears about 10 strong and sharp spines, of which 8 are arranged in combs of 4 on either side, and 2 along the mid-line (fig. 2, *f*). This pattern appears to be a constant and differential feature of anophelines.

The culicines on the other hand show considerable variation in this respect. In *Harpagomyia genurostris*, *Aëdomyia venustipes*, *Ficalbia* (*Ficalbia*) *minima* and *Heizmannia*, the posterior concavity, the basal prominence and the spines are considerably reduced. In *Heizmannia*, particularly, there is very little modification of the segment in the male, so that there is practically little difference between the two sexes on this basis (fig. 2, *b*, *c*, *d* and *e*).

In the genus *Culex* the basal prominence is very well developed and bears on its summit a transverse comb of about 5 sharp, short spines curving downwards, which in profile present a beak-like appearance. Lower down on each side of the basal prominence are one or two long bristles, and about the middle of the concavity a pair of small bristles each arising from a conical tubercle (fig. 2, *a*, *g*, g_1, g_2).

The above type of fifth fore-tarsal segment in the male is not, however, an exclusive feature of the genus *Culex*. It is equally characteristic of the subgenus *Aëdimorphus* of *Aëdes*, and to a less extent of *Ficalbia* (*Mimomyia*) *hybrida* and *Theobaldia longiareolata* (compare fig. 2, *a* and *g* with fig. 2, *h*, *i* and *j*). Other species have markedly different patterns of chaetotaxy,

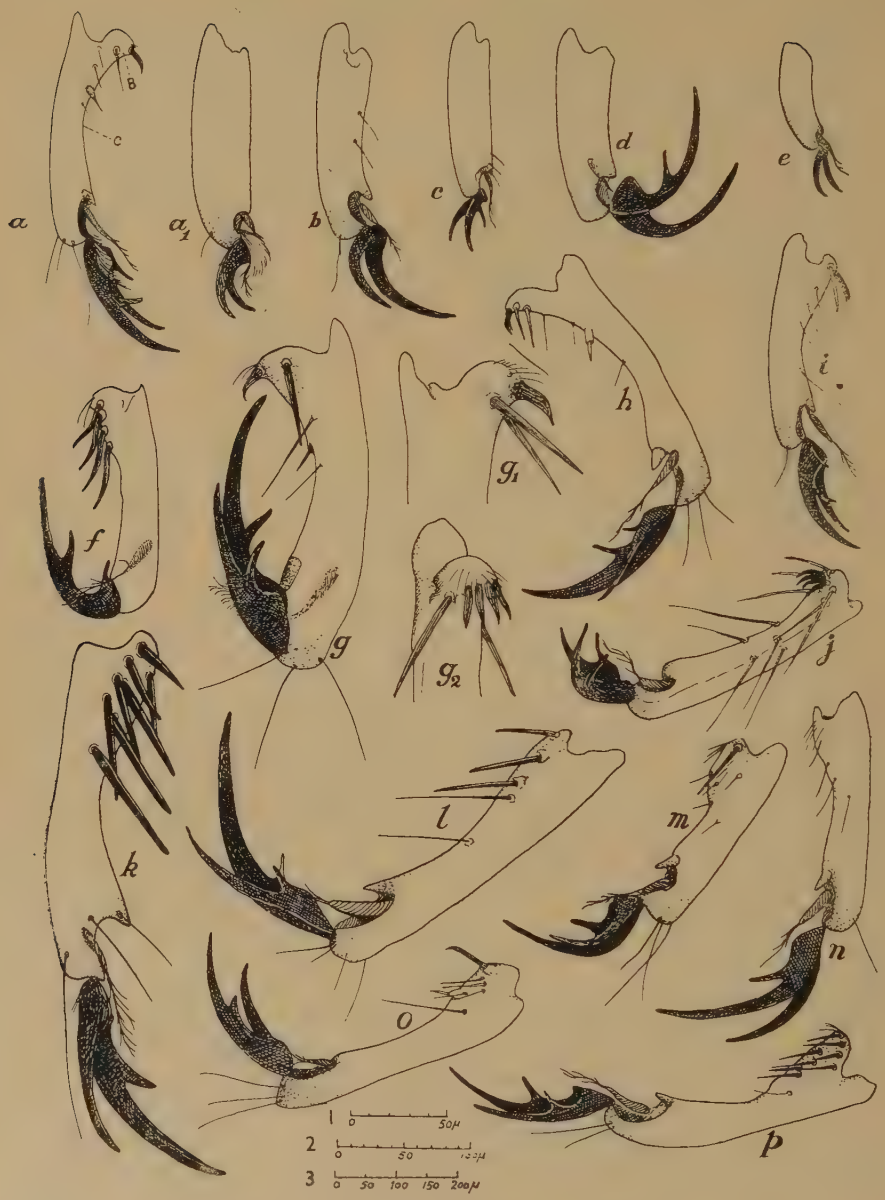

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FIG. 2.—Secondary sexual modification of the fifth fore-tarsal segment in male mosquitoes : (*a*) *Culex vishnui* ♂ (Scale *2*) ; (*B*) basal prominence ; (*C*) posterior concavity. (a_1) *Culex vishnui* ♀, for comparison with (*a*) (Scale *2*). (*b*) *Ficalbia minima* ♂ (Scale *1*). (*c*) *Heizmannia viridis* ♂ (Scale *2*). (*d*) *Aedomyia venustipes* ♂ (Scale *2*). (*e*) *Harpogomyia genurostris* ♂ (Scale *2*). (*f*) *Anopheles hyrcanus* var. *nigerrimus* ♂ (Scale *2*). (*g*) *Culex bitaeniorhynchus* ♂ (segment shown in the gripping position) (Scale *2*). (g_1) *Culex bitaeniorhynchus* ♂. Side view of basal prominence with the characteristic apical spines. Note the beak-like appearance (Scale *1*). (g_2) *Culex bitaeniorhynchus* ♂. Posterior view of basal prominence showing the apical comb of 4 spines (Scale *1*). (*h*) *Aëdes* (*Aëdimorphus*) *alboscutellatus* ♂ (Scale *2*). (*i*) *Ficalbia* (*Mimomyia*) *hybrida* ♂ (Scale *2*). (*j*) *Theobaldia longiareolata* ♂ (Scale *3*). (*k*) *Megarhinus splendens* ♂ (Scale *3*). (*l*) *Armigeres obturbans* ♂ (Scale *2*). (*m*) *Aëdes pseudomediofasciatus* ♂ (Scale *2*). (*n*) *Mansonia* (*Mansonioides*) *uniformis* ♂ (Scale *2*). (*o*) *Tripteroides affinis* ♂ (Scale *1*). (*p*) *Aëdes* (*Stegomyia*) *vittatus* ♂ (Scale *2*).

which do not seem to be distinctive enough to be regarded as of any generic or subgeneric significance (fig. 2, *k*, *l*, *m*, *n*, *o*, *p*).

It is obvious that in those species in which the fifth fore-tarsal segment in the males is specialized, it serves to aid the prehensile function of the claws.[2] The claws which are dorsally hinged on to the segment are capable of being opened and closed like the blade of a clasp knife. The flexion of the claws, as in other insects (Snodgrass, 1935), is effected by means of a tendon-like depressor or retractor muscle attached to the base of the empodium which is situated in the middle of the pretarsus, slightly posterior to the claws. The curvature of the claws corresponds to the posterior concavity of the segment (fig. 2, *g*), so that by closing them the insect is able to obtain a good grip of any slender object. The subterminal notch snugly holds the bases of the claws when folded, and the various spines and bristles help keep the grip firm. The utility of this device became evident during the course of observations on the mating activities of *Stegomyia vittatus* and *Armigeres obturbans*.

Prior to copulation, a male mosquito chases a female until he gets hold of her hind pair of legs with his fore pair. Very rarely the mid pair of legs may come into play. If at this time the female happens to fall down or come to rest, the male, without losing hold of his mate, swiftly wriggles beneath her and copulation takes place in the face-to-face position. If, on the other hand, the female still flies about, the male may often be seen dangling from her hind legs until both fall down or come to rest. Females have been observed to carry their dangling mates in this way for nearly half a minute. It is clear that this piece of aerobatics[3] on the part of the male, which seems to be an essential prelude to pairing, is made possible by the specialization of the fifth fore-tarsal segment into a sort of prehensile organ.

The manner in which the male gets hold of the female can be observed under a binocular microscope, as follows :

A male and a female of *Stegomyia vittatus* are lightly anaesthetized with chloroform, and their wings cut off. After revival the female is placed in a petri dish and gently poked with a dissection needle into the normal resting posture. The male is then held by the tip of its abdomen between a pair of fine forceps, brought near the female and allowed to grasp her by her legs, which he readily does. The pair can be conveniently observed in this condition under a binocular microscope. The legs of the female can then be seen to be held in a tight clasp between the claws and the fore-tarsal segment of the male.

3. Hairs on the Remigium or Stem-Vein (fig. 3).

The remigium or stem-vein in several species carries a few hairs along its posterio-dorsal margin. These hairs may be short or long. When short,

[2] The part played by the claws of the first pair of legs of the male as gripping organs during copulation has been mentioned by Martini (1929). But there is no reference yet to the accessory function of the specialized fifth fore-tarsal segment.

[3] Russell and Mohan (1939), who studied the swarming and pairing of *Anopheles stephensi*, made the following observation : " In some pairs the females were sitting on the side of the cage, males hanging down without any support, and *vice versa*." Though very rarely a female may be seen to dangle for a short while from a resting male after copulation, the present author has never seen a female perform this feat while the male is on the wing.

they may be partly or wholly hidden by the remigial scales. In such cases their detection depends on whether the scales are intact or have been rubbed off. Thus in a fresh specimen they may apparently be wanting, while in a denuded specimen of the same species they may show up clearly. When well developed these hairs almost overhang the base of the 4th vein and can easily be recognized (fig. 3, *a*, *c*).

The remigial hairs are distinct from the subcostal hairs characteristic of the genus *Theobaldia*, which Dyar and Shannon (1924)[4] first described as

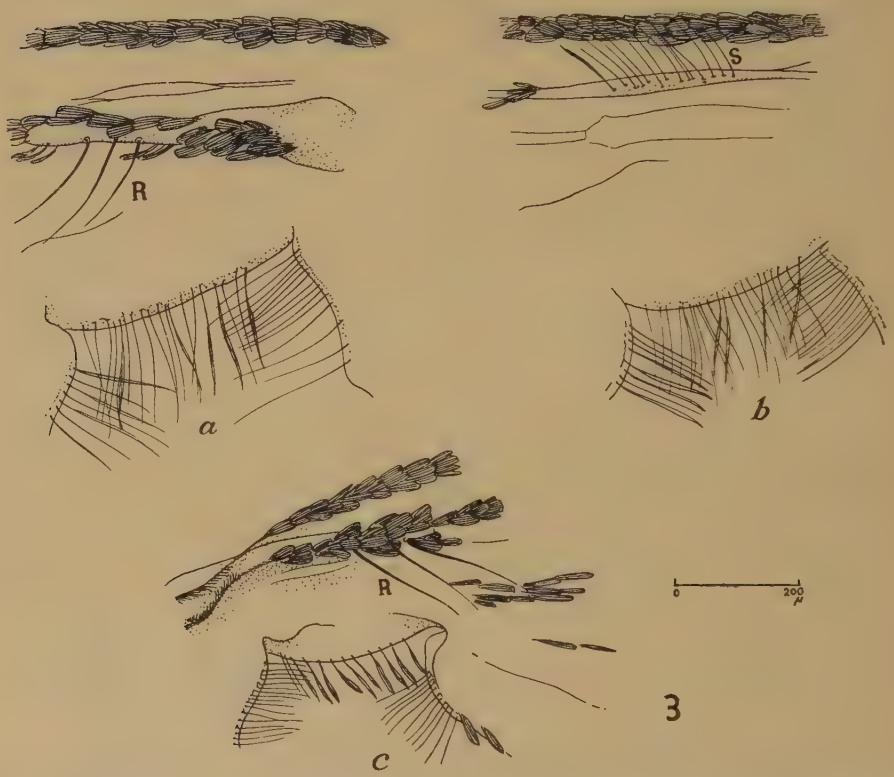

Fig. 3.—Remigial hairs in mosquitoes:—(*a*) *Theobaldia longiareolata:* Wing base from above, showing the three well-developed remigial hairs (R). (*b*) *Theobaldia longiareolata:* Wing base from beneath, showing the subcostal hairs (S). (*c*) *Culex fatigans:* Wing base showing three well-developed remigial hairs (R).

arising ventrally from the remigium, but which, as subsequently pointed out by Edwards (1934) in a footnote to Barraud's (1934) description of the genus, actually start from the subcosta. The subcostal hairs, being ventral in position, can best be seen from below, whereas the remigial hairs, being dorsal, are visible only from above (fig. 3, compare *a* and *b*).

The taxonomic importance of remigial hairs does not appear to have been sufficiently investigated, even though some American workers, Aitken (1939)

[4] This reference has not been consulted in the original by the author.

and Kenneth *et al.* (1944), have mentioned the presence of these hairs as a useful diagnostic character of the genera *Aëdes* and *Armigeres*. Aitken (*loc. cit.*) refers to the presence of setae " on upper side of base of R_1 (1st vein) " as a characteristic of *Aëdes*, " when wing scales are broad." According to Kenneth *et al.* (*loc. cit.*), " usually a few hairs on the upper surface of stem vein " is characteristic of *Aëdes* and *Armigeres*.

From the present study, which includes one species of *Armigeres* and 10 of *Aëdes* belonging to 5 subgenera, it has been found that remigial hairs and broad wing scales need not always go together as claimed by Aitken(*loc. cit.*) ; nor do the hairs occur so frequently in all the species as to constitute a generic character of *Aëdes*, as implied by Kenneth *et al.* For example, all the four species of the subgenus *Aëdimorphus* studied have linear wing scales, but show long and very well developed remigial hairs. In species of the subgenus *Stegomyia* and in *Banksinella lineatopennis*, the remigial hairs are absent. In *Aëdes* (*sensu stricto*), *Finlaya* and *Armigeres*, they are short and inconspicuous, being usually hidden by the remigial scales. It would thus appear that the presence of remigial hairs cannot be regarded as a reliable generic character of *Aëdes* or *Armigeres*, even though, as the present study has indicated, it would be of diagnostic use for the separation of *Aëdimorphus* from the other subgenera of *Aëdes*.

Apart from *Aëdes* and *Armigeres*, no other genus has been so far recorded as having remigial hairs. In the present series, however, their presence has been found to be an invariable character of the genus *Culex* (fig. 3, *c*). All the 17 species belonging to the 6 genera studied possess 2 to 5 very prominent remigial hairs. Even in some of the small species, such as those belonging to the subgenus *Mocthogenes* and *Lophoceratomyia*, the hairs are conspicuous enough for easy recognition. In the writer's experience, the diagnostic value of this character for the differentiation of *Culex* has been found to be no less than that of the presence of pulvilli, when taken along with " the absence of spiracular and post-spiracular hairs."

Of the remaining species examined, only *Theobaldia longiareolata* had remigial hairs, 3 long and well developed ones. As already pointed out, these are quite distinct from the ventrally-placed subcostal hairs, the presence of which is an important differential character of the genus *Theobaldia* (compare *a* and *b*, fig. 3).

Conclusions.

Admittedly it is premature at this stage to draw any definite conclusions in regard to the taxonomic significance of the characters described above. Much more material with wider generic and geographic representation needs to be examined before that can be done. There is, however, no doubt that the observations made do justify some tentative inferences, which are summarized below.

Summary.

1. The presence of two rows of bud-like sensillae on the fore and mid tarsi in Culicines, on the fore-tarsus alone in Anophelines and their absence in *Megarhinus* would seem to constitute a fundamental taxonomic difference between the three tribes, Culicini, Anophelini and Megarhinini.

2. Secondary sexual modification of the fifth foretarsal segment of the male appears to be a general feature of most species of mosquitoes. The absence of any modification of the segment is a distinguishing feature of the genus *Heizmannia*. The shape and chaetotaxy of the segment in the genus *Culex* and in the subgenus *Aëdimorphus* of *Aëdes*, viz., the presence of a comb of curved spines at the apex of a well-developed basal prominence, should be helpful when taken along with other generic characters, in the differentiation of *Culex* from other genera of mosquitoes and *Aëdimorphus* from other subgenera of *Aëdes*.

3. The presence of conspicuous hairs on the remigium (stem-vein) is a clinching diagnostic character of the genus *Culex* and of the subgenus *Adëimorphus*, when considered along with other generic characters.

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APPENDIX.

(List of species studied.)

Megarhinini :

1. *Megarhinus splendens* (Wied).

Culicini :

1. *Tripteroides affinis* Giles.
2. *Harpagomyia genurostris* (Leic.).
3. *Uranotaenia alboannulata* (Theo.).
4. *Theobaldia longiareolata* (Macq.).
5. *Ficalbia* (*Mimomyia*) *chamberlaini* (Ludl.).
6. *F.* (*Mimomyia*) *hybrida* (Leic.).
7. *F.* (*Ficalbia*) *minima* (Theo.).
8. *Mansonia* (*Mansonioides*) *annulifera* (Theo.).
9. *M.* (*Mansonioides*) *longipalpis* (Van der Wulp).
10. *M.* (*Mansonioides*) *uniformis* (Theo.).
11. *M.* (*Mansonioides*) *indiana* (Edw.).
12. *Aëdomyia venustipes* (Skuse).
13. *Aëdes* (*Finlaya*) *gubernatoris* (Giles).
14. *A.* (*Stegomyia*) *albopictus* (Skuse).
15. *A.* (*Stegomyia*) *vittatus* (Bigot).
16. *A.* (*Aëdimorphus*) *jamesi* (Edw.).
17. *A.* (*Aëdimorphus*) *alboscutellatus* (Theo.).
18. *A.* (*Aëdimorphus*) *pipersalatus* (Giles).
19. *A.* (*Aëdimorphus*) *ostentatio* (Leic.).
20. *A.* (*Banksinella*) *lineatopennis* (Ludl.).
21. *A.* (*Aëdes*) *pseudomediofasciatus* (Theo.).
22. *A.* (*Aëdes*) *seculatus* sp.n. Menon.*
23. *Heizmannia viridis* Barraud.
24. *H. chandi* Edwards.
25. *Armigeres obturbans* (Walk.).
26. *Culex* (*Lutzia*) *fuscanus* (Weid.).
27. *C.* (*Neoculex*) *brevipalpis* (Giles).
28. *C.* (*Mocthogenes*) *malayi* (Leic.).
29. *C.* (*Lophoceratomyia*) *minutissimus* (Theo.).
30. *C.* (*Lophoceratomyia*) *parainfantulus* Menon.
31. *C.* (*Culiciomyia*) *pallidothorax* (Theo.).
32. *C.* (*Culiciomyia*) *nigropunctatus* Edw.
33. *C.* (*Culex*) *bitaeniorhynchus* Giles.
34. *C.* (*Culex*) *sitiens* Wied.
35. *C.* (*Culex*) *vishnui* Theo.
36. *C.* (*Culex*) *tritaeniorhynchus* Giles.
37. *C.* (*Culex*) *whitmorei* Giles.
38. *C.* (*Culex*) *gelidus* Theo.
39. *C.* (*Culex*) *theileri* Theo.
40. *C.* (*Culex*) *vagans* Wied.
41. *C.* (*Culex*) *fatigans* Wied.
42. *C.* (*Culex*) *fuscocephalus* Theo.

* Description in Press.

Anophelini :

1. *Anopheles insulaeflorum* Swell. and Swell.
2. *A.* (*Lophocelomyia*) *annandallei* B. Prasad.
3. *A.* (*Myzorhynchus*) *hyrcanus* var. *nigerrimus* Giles.
4. *A.* (*Myzorhynchus*) *barbirostris* Van der Wulp.
5. *A.* (*Neomyzomyia*) *leucosphyrus* Don.
6. *A.* (*Neomyzomyia*) *tessellatus* Theo.
7. *A.* (*Myzomyia*) *culicifacies* Giles.
8. *A.* (*Myzomyia*) *fluviatilis* James.
9. *A.* (*Myzomyia*) *varuna* Iyengar.
10. *A.* (*Myzomyia*) *aconitus* Don.
11. *A.* (*Myzomyia*) *jeyporiensis* James.
12. *A.* (*Pseudomyzomia*) *subpictus* Grassi.
13. *A.* (*Pseudomyzomia*) *vagus* Don.
14. *A.* (*Neocellia*) *jamesi* Theo.
15. *A.* (*Neocellia*) *karwari* James.
16. *A.* (*Neocellia*) *annularis* Van der Wulp.
17. *A.* (*Neocellia*) *philippinensis* Ludl.
18. *A.* (*Neocellia*) *pallidus* Theo.

Book Notice

Insects and Hygiene: The Biology and Control of Insect Pests of Medical and General Importance in Britain. By J. R. Busvine. 8vo. London (Methuen), 1951. Pp. xiv + 482, 58 figures. Price 30*s*.

A comprehensive handbook of domestic entomology. Mites and ticks as well as true insects are included, and the schedule comprises houseflies and blowflies; all the allied flies of domestic importance; bloodsucking flies; parasites, such as bedbugs, fleas, lice, mites and ticks; pests of foodstuffs; waste products of sewage; clothes moths and carpet beetles; woodborers; stinging and biting insects; and "nuisances."

General chapters summarize the importance of insects in hygiene, their structure and classification, anatomy and physiology, and ecology. There are chapters on the organization of preventive and control measures, and on insecticides. Technical data are collected into a Biological Appendix, with simplified keys, and a Chemical Appendix, which includes methods of sampling and estimating some of the standard fumigants and insecticides, and an alphabetic glossary of relevant names and formulae.

The emphasis throughout is on the practical problems of recognition, economic importance and control, and a great deal of information is collated and abundantly documented. The illustrations of insects are mostly said to be "after" other authors, but they depart so far from the originals in style and treatment that the acknowledgement is hardly appropriate.

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Wednesday, August 15
,, October 3
,, November 7
,, December 5

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